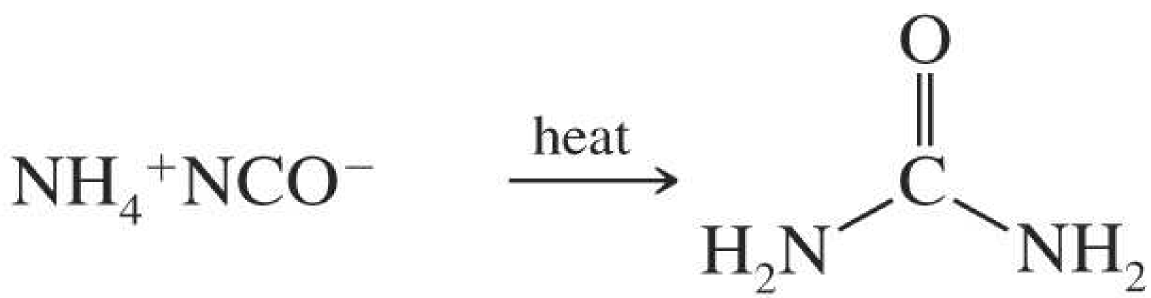
What is Organic chemistry?

- **Historical**
  - **“Organic” – derived from living organisms**
  - **Compounds such as sugar, urea, starch**
  - **Vitalism: natural products needed a “VitalForce” to create them**
  - **Wöhler (1828) synthesis of urea**



Ammonium cyanate **Urea**

Inorganic Organic

Organic Chemistry Today

The study of compounds and reactions involving carbon, regardless of source **(Kekulé, 1861)**

"Natural products" – from living organisms
"Biochemistry" – the chemistry that occurs in living organisms

Organic Vegetables, Natural Vitamins from extracts

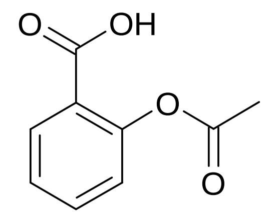
Why should we care?

– ***Biochemistry***

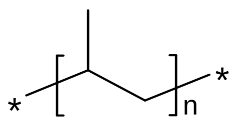
– ***Pharmaceuticals***

– ***Industry***

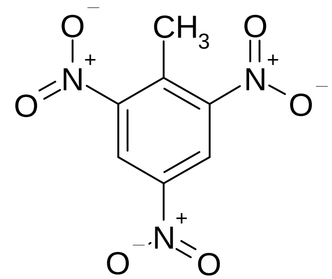
  - ***Polymers***
  - ***Explosives***



Acetyl Salicylic acid



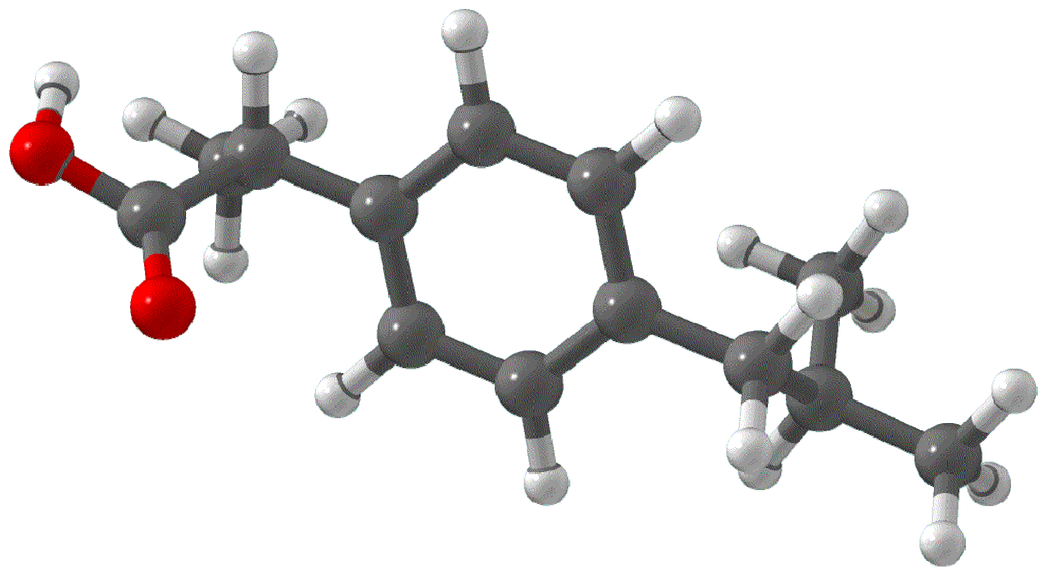
Polypropylene

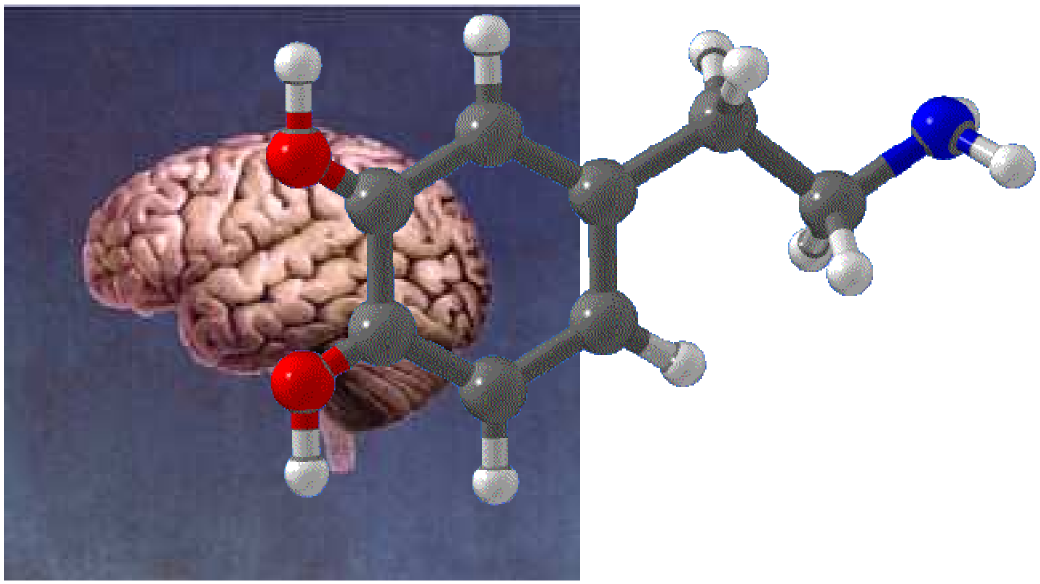


2,4,6-Trinitrotoluene

The three dimensional nature of molecules, such as ibuprofen, is fundamental to all of their properties including biological behavior.

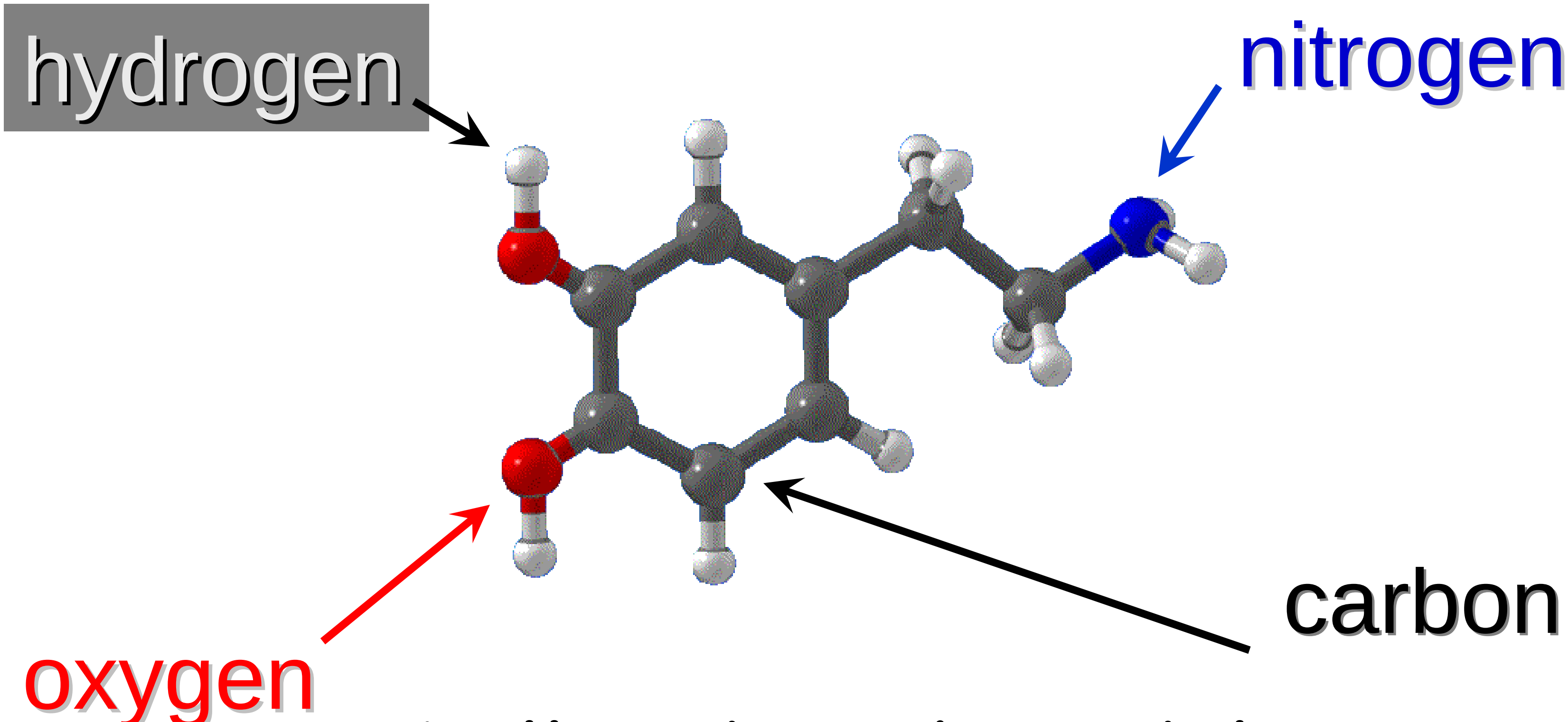
$C_{13}H_{18}O_2$





the brain **dopamine**

Dopamine
a neurotransmitter
present in the brain



a ball and stick model

Organic Chemistry

An **organic compound**

- is a compound made from carbon atoms.
- has one or more C atoms.
- has many H atoms.
- may also contain O, S, N, and halogens.

Organic Compounds

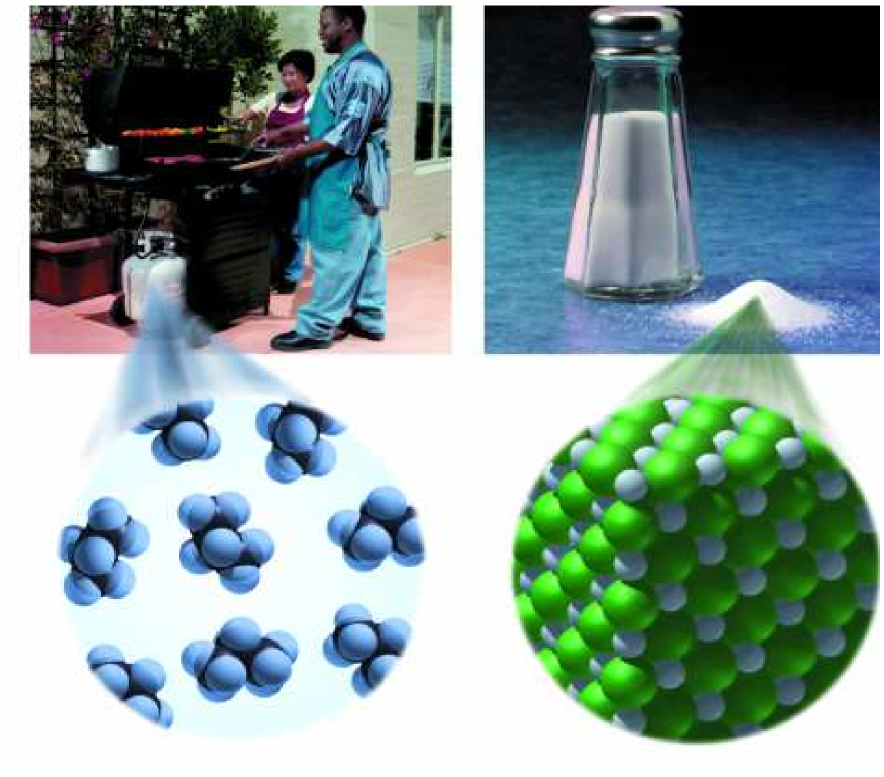
Typical organic compounds

- have covalent bonds.
- have low melting points.
- have low boiling points.
- are flammable.
- are soluble in nonpolar solvents.
- are not soluble in water.

oil (organic) and water (inorganic)

Organic vs. Inorganic

- Propane, C_3H_8, is an organic compound used as a fuel.
- NaCl, salt, is an inorganic compound composed of Na^+ and Cl^- ions.



Learning Check

Identify each characteristic as most typical of compounds that are 1) inorganic 2) organic.

A. has a high melting point

B. is not soluble in water

C. has a formula $CH_3{-}CH_2{-}CH_3$

D. has a formula $MgCl_2$

E. burns easily in air

F. has covalent bonds

Solution

Identify each characteristic as most typical of compounds that are 1) inorganic 2) organic.

_1_ A. has a high melting point

_2_ B. is not soluble in water

_2_ C. has a formula $CH_3—CH_2—CH_3$

_1_ D. has a formula $MgCl_2$

_2_ E. burns easily in air

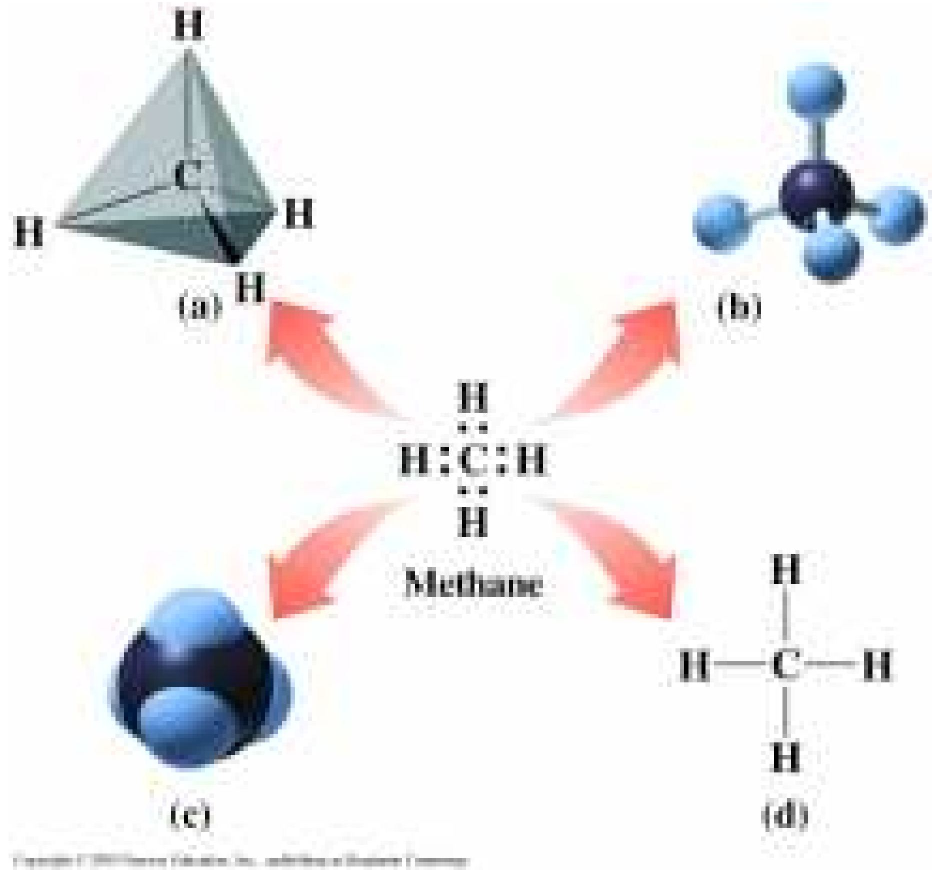
_2_ F. has covalent bonds

Comparing Organic and Inorganic Compounds

Property	Organic	Inorganic
Bonding	Mostly covalent	Many are ionic, some covalent
Polarity of bonds	Nonpolar, unless a more electronegative atom is presen	Most are ionic or polar covalent, a few are nonpolar covalent
Melting point	Usually low	Usually high
Boiling point	Usually low	Usually high
Flammability	High	Low
Solubility in water	Not soluble, unless a polar group is present	Most are soluble, unless nonpolar

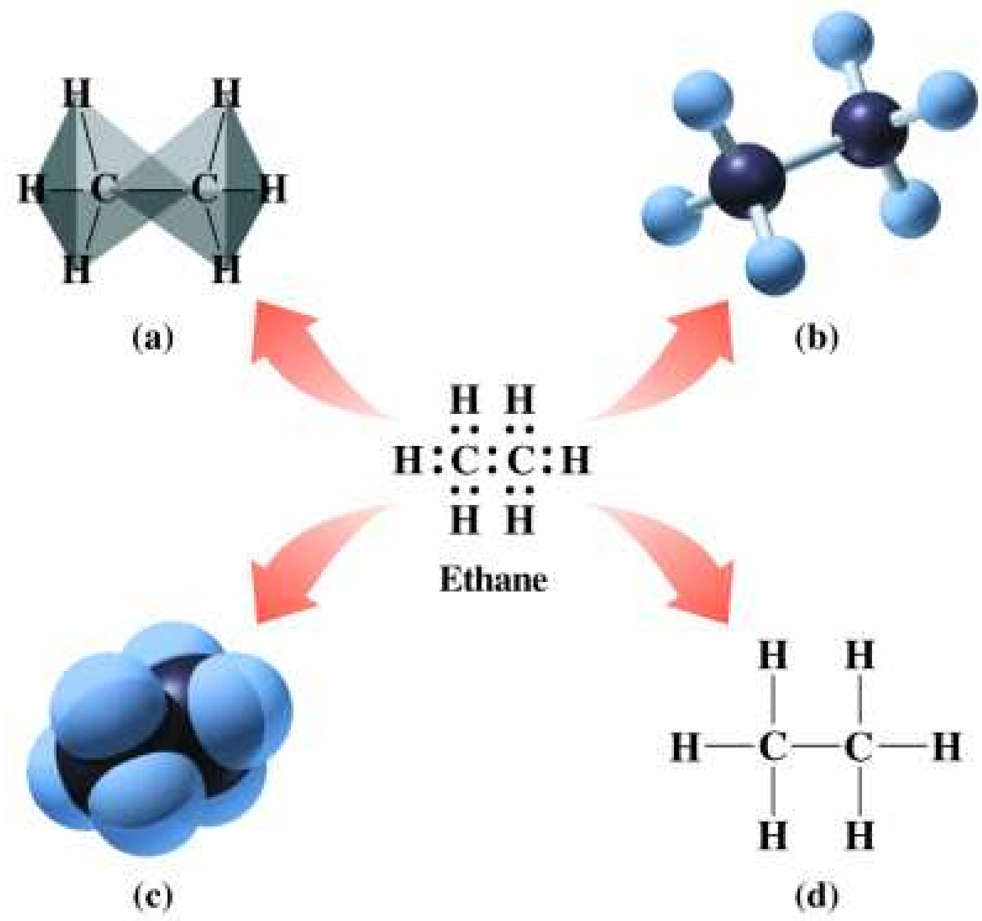
Tetrahedral Structure of Carbon

VSEPR theory predicts that a carbon atom with four single, covalent bonds, has a tetrahedral shape.



Tetrahedral Structure of Carbon

In molecules with two or more carbon atoms, each carbon atom with four single bonds has a tetrahedral shape.



First we are going to explore isomerism!

To give you an idea:

There are many compounds that have same chemical formula but different structures.

Example: C_4H_{10}

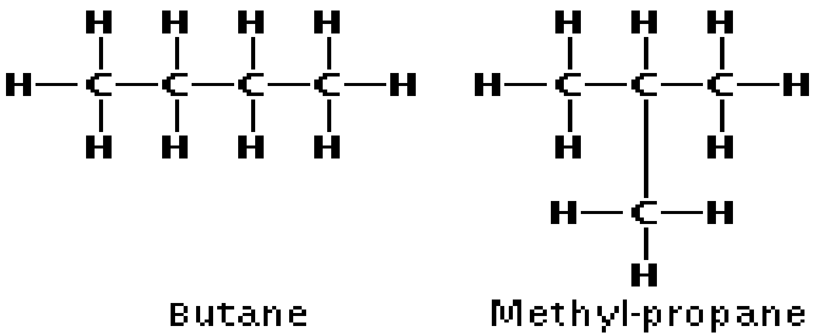


Figure 3

Stereochemistry

The Two Major Classes of Isomers

- **Isomers are different compounds with the same molecular formula.**
- **The two major classes of isomers are constitutional isomers and stereoisomers.**
  - **Constitutional/structural isomers have different IUPAC names, the same or different functional groups, different physical properties and different chemical properties.**
  - **Stereoisomers differ only in the way the atoms are oriented in space. They have identical IUPAC names (except for a prefix like *cis* or *trans*). They always have the same functional group(s).**
- **A particular three-dimensional arrangement is called a configuration. Stereoisomers differ in configuration.**

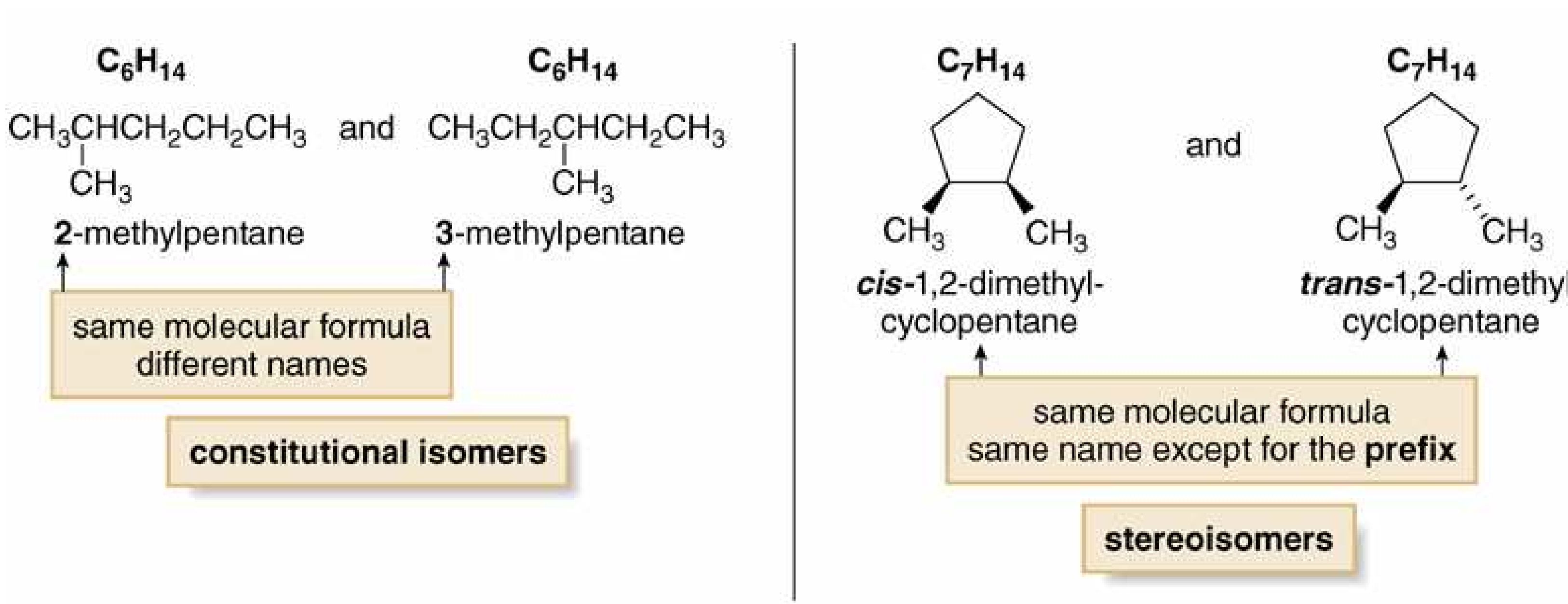
Constitutional isomers

- Structural isomers have the same molecular formulas but they differ in their structural formulas.

Try to give me the all the structural isomers of C_5H_{12}.

Figure 5.3

A comparison of consitutional isomers and stereoisomers



Stereoisomers or Geometrical isomers

- Geometrical isomers occur in organic molecules where rotation around a bond is restricted
- This occurs most often around C=C
- The most common cases are around asymmetric non-cyclic alkenes

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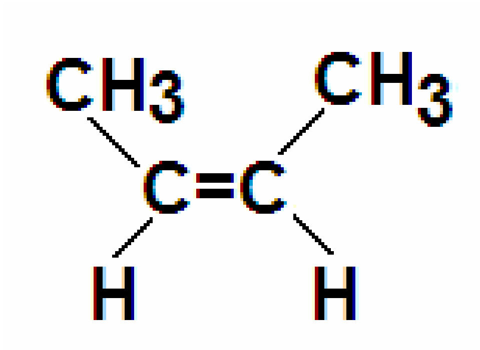
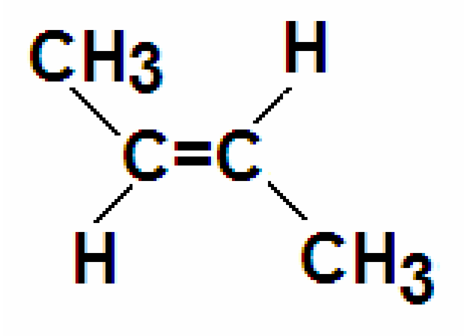
Geometric Isomers in alkenes

- A cis isomer is one in which the substituents are on the same side of the C=C



- A trans isomer is one in which the substituents are on the opposite sides of the C=C



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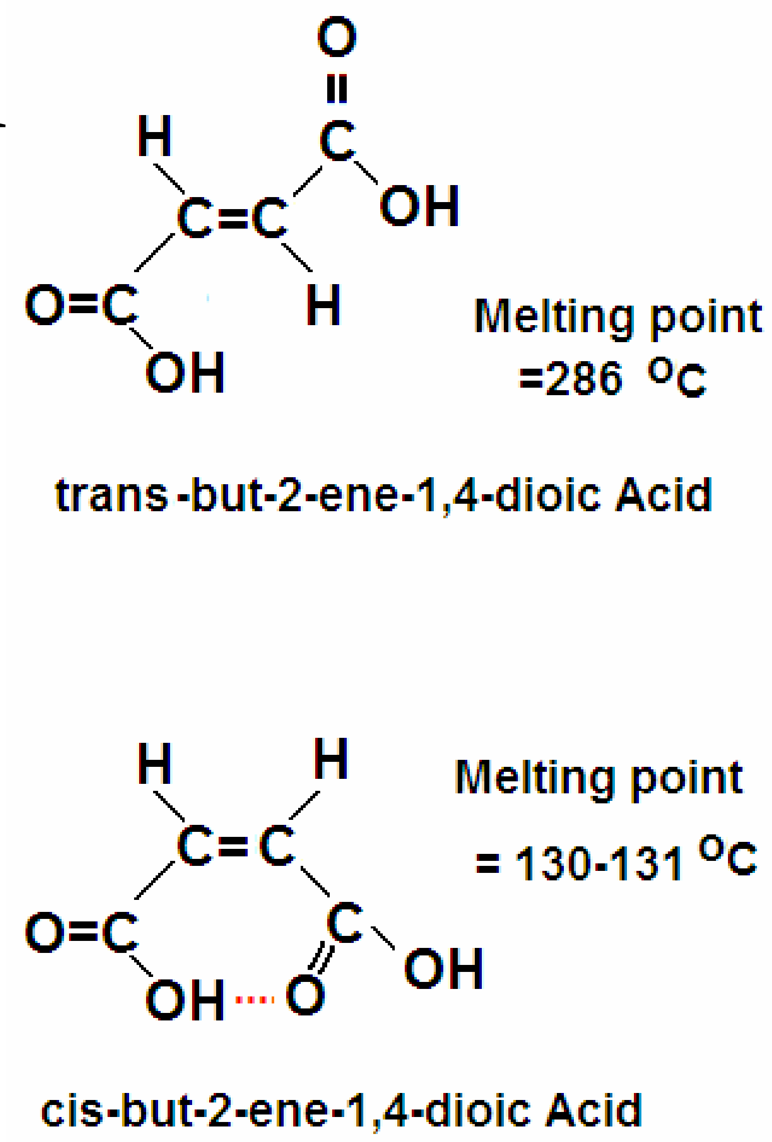
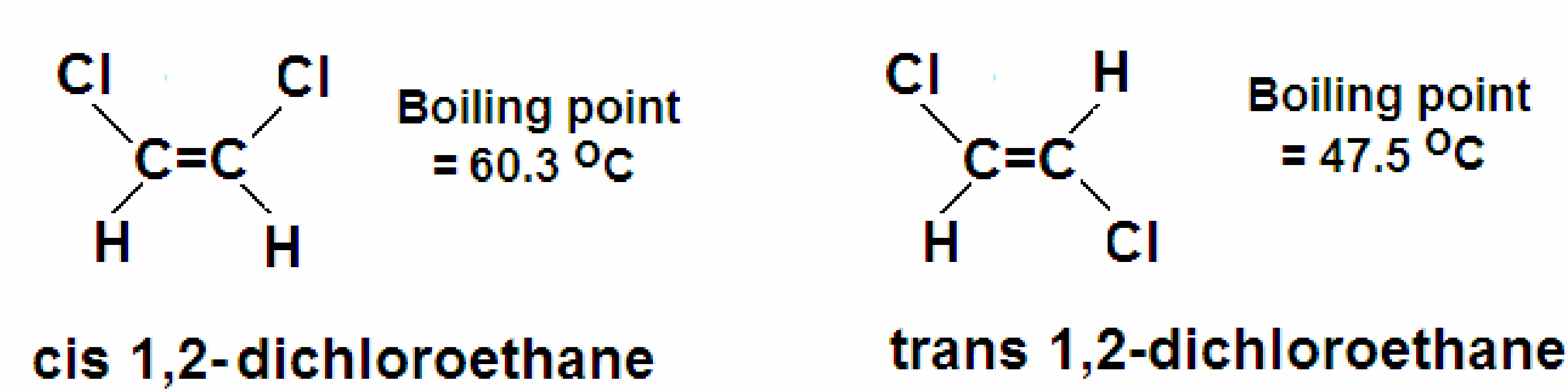
Properties of Geometrical Isom



The trans isomer has a much higher melting point. Unlike the cis isomer there is little intra-molecular hydrogen bonding

Properties of Geometrical Isomers

The chemical properties of geometrical isomers tend to be similar but their physical properties are different



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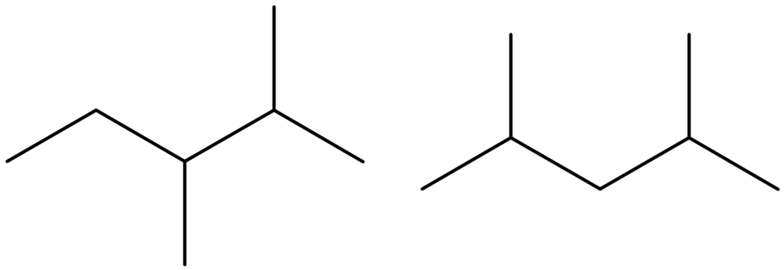
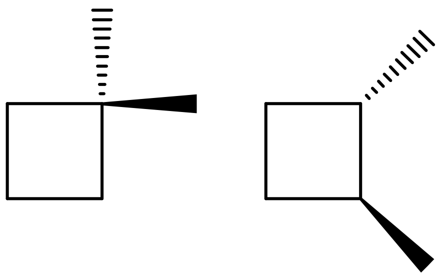
Are the following pairs of compounds consitutional isomers or stereoisomers?

a)



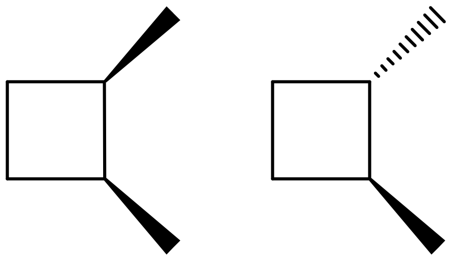
constitutional

b)



constitutional

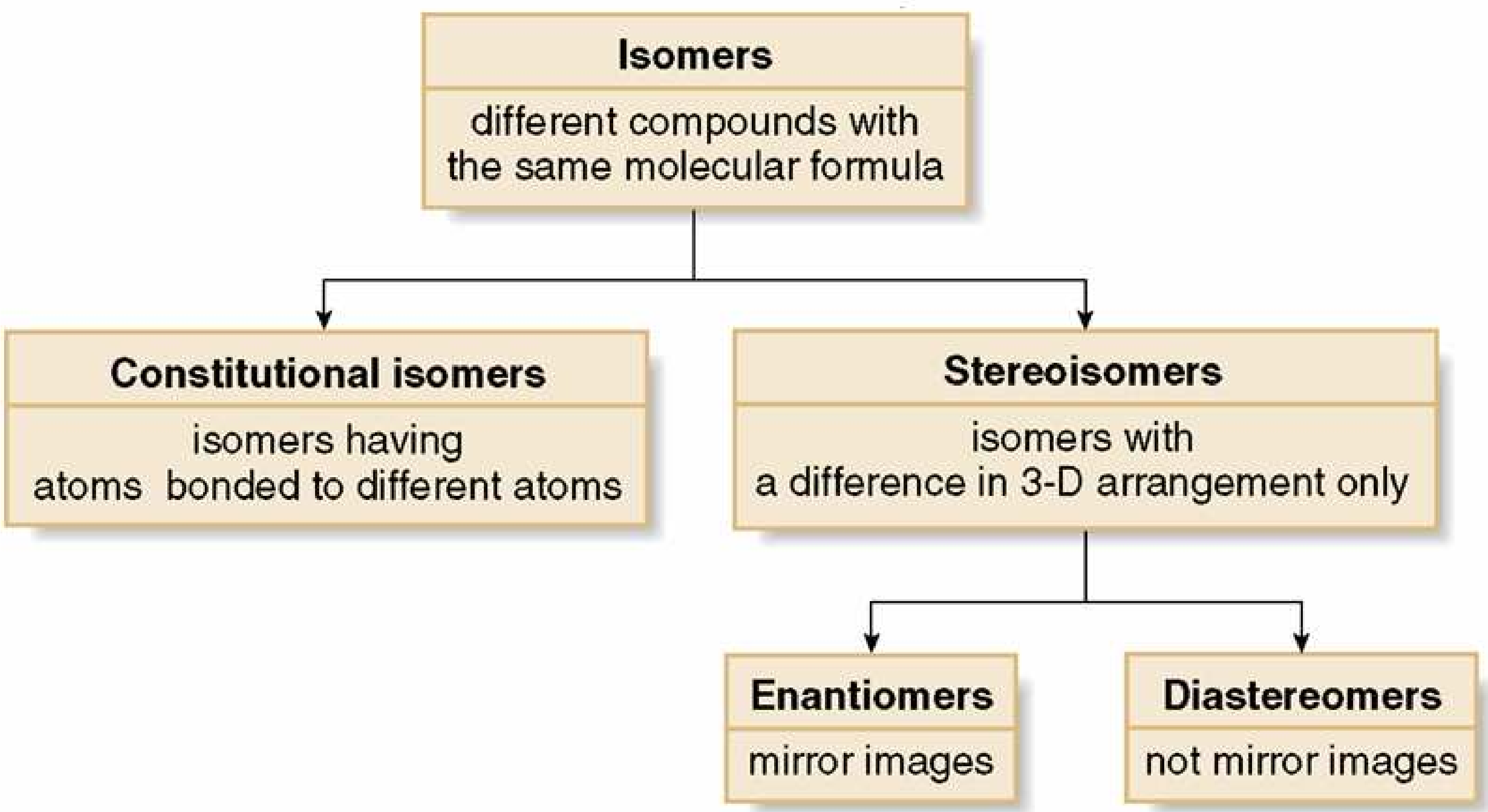
c)



stereoisomer

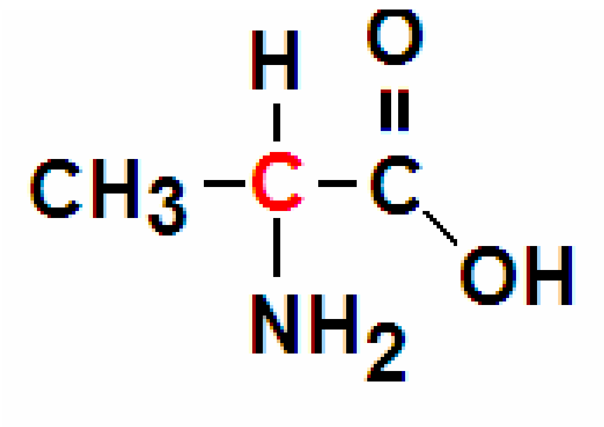
Figure 5.10

Summary—Types of isomers



Enantiomers

- **Enantiomers must have an asymmetric carbon. (called chiral carbon)**
- **An asymmetric carbon atom has four different atoms or groups attached**



In this case there are two different ways to arrange the four groups around the chiral carbon atom (shown in red)

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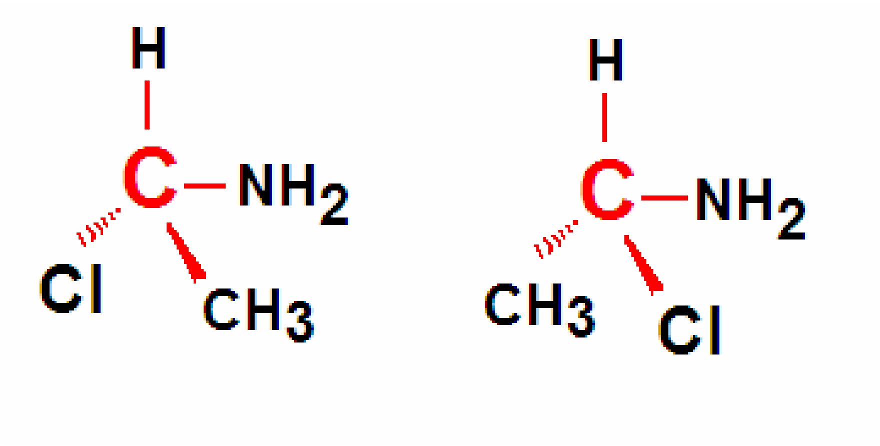
Enatiomers are mirror images of each other around a chiral carbon

While these structures may look identical, in three dimensions they are mirror images of each other. Such molecules are called **enantiomers**.



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